AMAN KUMAR SINGH | 20AE30032
AEROSPACE ENGINEERING (M. Tech Dual 5Y)
MICRO SPL. in HIGH-PERFORMANCE COMPUTING AND APPLICATIONS

EDUCATION

Year	Degree/Exam	Institute	CGPA
2025	M.TECH Dual Degree 5Y	Indian Institute of Technology, Kharagpur	8.58/10

PAPERS (IN-PREPARATION)

Journal of Computational Physics (IN-PREPARATION) | Prof. Sandeep Saha

1. *A Reconstruction-based Spectral Method for Helmholtz Equation with Discontinuous Coefficients and Interfaces Using Correction Functions*
   - Developed a novel reconstruction technique to address the Gibbs-Wilbraham phenomenon in Helmholtz equations, improving accuracy and convergence for problemswith sharp interfaces and discontinuous coefficients. **(IN-PREPARATION)**

2. *A global correction function method-based Chebyshev solver for Poisson equation*
   - Developed a correction function method to address the Gibbs-Wilbraham phenomenon in spectral methods, solving interface discontinuities by formulating a globally-defined differential equation that satisfies jump conditions at the interface for Poisson Equation. **(IN-PREPARATION)**

CONFERENCES

77th Annual Meeting of the Division of Fluid Dynamics **| APS DFD | Salt Lake City, USA | Session Chair:** Prof. Gretar Tryggvason **[Nov'24]**

- **Title**: A Reconstruction based exponentially accurate spectral method to solve Elliptic PDEs with discontinuous coefficients and complex shaped interfaces.
- Explained the challenges of accurately solving elliptic PDEs with discontinuous coefficients, across complex interfaces, where traditional methods fall short.
- Presented our reconstruction-based spectral approach, which overcomes these to achieve exponential convergence and near machine-level accuracy.

INTERNSHIPS

Cooperative Automated Driving (Onsite) **| MITACS GRI | University of Windsor, Canada | Prof. Ahmed Hamdi Sakr** **[May'23-Jul'23]**

- **Autonomous Stack:** Implemented ROS autonomous stack for cooperative driving scenario, & used multi-sensor fusion (IMU, Odometry Data) for navigation.
- **Perception & Control:** Integrated depth sensing, object detection/tracking, and lane detection, combined with PID feedforward control for speed regulation.
- **Sensor Fusion & EKF:** Fused IMU & encoder using Extended Kalman Filter for state estimation and used Adaptive Cruise Control for headway management.

Autonomous Tractor **| Engineering Intern (Onsite) | Aliyance Mechatronics (R&D), LLC (Saskatchewan, Canada based)** **[Jun'22-Jul'22]**

- **Simulation:** Developed ROS-based 1:1 scale digital twin for Barnstormer v1.1 autonomous tractor, with path planning and waypoint navigation on a field.
- **RTK-GPS**: Fused RTK-GPS (ZED-F9P) with odometry using Extended Kalman Filter on prototype, and achieved 2 cm min accuracy in real-world localization.
- **Obstacle Avoidance:** Implemented dynamic obstacle avoidance on the prototype model using Teb Local Planner, for navigation around obstacles real-time.

PROJECTS

Pipeline for Pick & Place using Serial Manipulators and Stereo Vision **| Freelancing** **[Jan'24-Feb'24]**

- **Pick-and-Place Robot:** Worked on Mycobot 280 Jetson system with MoveIt, using stereo vision, YOLOv8, and DBSCAN for object detection and localization.
- **Kinematics and Operation:** Used inverse/forward kinematics for motion planning, to enable the pick-and-place tasks through a scripted execution in Moveit.
- **Human Imitation:** Developed computer vision scripts for human action imitation, allowing the robot to place or hand over objects based on given video input.

NASAs Ingenuity Helicopter Simulation **| Flight Testing Lab | IIT Kharagpur | Prof. Sandeep Saha** **[Sep'22-Dec'22]**

- **Atmospheric and Rotor Modelling:** Used Mars atmospheric model, modelled battery system with thermal control, solar panel, and co-axial rotor dynamics.
- **Control Implementation:** Used 6-DOF motion equation, designed PID based altitude controller, and sliding mode controller for moving in x and y directions.

COMPETITIONS

Fault Tolerant Control of Quadrotor with Single Motor Failure | Team Captain | InterIIT Tech Meet 13th Edition | IIT Bombay, India **[Oct'24-Current]**

- **Captain**: Led team of 8 members to build fault detection & control strategy for stabilization during a motor failure on quadrotor, on simulation and hardware.
- **Fault Detection**: Built a Motor Failure Detector Module for the PX4 Firmware to detect faulty motor, using data from sensors and control inputs to the drone.
- **Control Strategy:** Guided the team to build solutions on multiple approaches like LQR, Backstepping Control, Non Linear Dynamic Inversion and simple PID.
- **Control Module:** Built the control module for PX4 Firmware to stabilize the quadrotor during motor fail, based on the Non Linear Dynamic Inversion approach.
- **Hardware:** Experiments shows success in the fault detection approach on Quadrotor with 60ms average detection latency. Achieved attitude stabilization.

Autodrive F1TENTH Sim Racing League **| International Conference on Intelligent Robots and Systems (IROS) 2024 | Team Phoenix** **[Oct'24]**

- **Achievement:** Placed fifth in second round of 58 teams of simulated autonomous racing, qualified through first round based on performance of the controller.
- **SLAM, Localization:** Performed SLAM-based mapping, used LIDAR, IMU and Odometry data for localization, fused sensor data via Extended Kalman Filter.
- **Control & Optimization:** Performed race line extraction using Computer Vision and used Pure Pursuit and LQR controllers for the autonomous vehicle control.

COMPETITIONS

Autonomous Weeder | Captain | Hardware Modelling | Gymkhana Championship - 2024 **[Feb'24-Mar'24]**
- **Project Leadership**: Led a team of ten students to develop an Autonomous Weeder for inter-row and intra-row weed management in agriculture setting.
- **System Integration**: Guided the model design and integration of drive system, perception, localization, control systems, along with battery management.
- **Vehicle Model Design**: Designed the mechanical model for Autonomous Weeder, collaborating with the team to create CAD-based design for fabrication.
- **Logistics Management**: Coordinated component procurement from suppliers, supervised welding & assembly processes, and managed logistical aspects.

Drone Swarming Competition for Two Drones | InterIIT Tech Meet 11th Edition | IIT Kanpur, India | Gold Winner **[Jan'23-Feb'23]**
- **Image Processing**: Developed a vision pipeline using Intel RealSense D435i camera to detect, estimate and track fiducial markers' positions on the drone.
- **Extended Kalman Filter (EKF)**: Created a Extended Kalman filter script to fuse IMU data, Aruco positions, and depth camera data for position estimation.
- **Non-Linear Dynamics Modeling:** Modelled the drone's non-linear dynamics and wrote a code to integrate them into EKF and model predictive controller.

Line Following Drone | MathWorks MATLAB Minidrone Competition 2022, India | IIT Kanpur | 1st Round Winner **[Jun'22-Oct'22]**
- **Image Processing**: Applied image processing to extract well-lit path for drone to follow, generating waypoint s for autonomous navigation along the path.
- **Longitudinal Control**: Built a heading-speed controller based on proximity and angle of upcoming turns, to prevent overshooting during sharp maneuvers.
- **Lateral Control**: Implemented PID-based controller to minimize lateral deviation from the path, ensuring that drone stays aligned with intended route.

Search Rescue using Drone & Amphibious Vehicle | Hardware Modelling | Gymkhana Championship - 2023 | Silver Winner **[Feb'23-Mar'23]**
- **Drone Building and FSM Design**: Built a quadrotor using Pixhawk and Jetson Nano for autonomous flight and engineered Finite State Machine on Ardupilot.
- **DJI Tello**: Developed scripts for performing localization and waypoint navigation using the Monocular Visual-Inertial ORB SLAM on the DJI Tello drone.
- **Amphibious Vehicle Control**: Implemented low-level motor control scripts for amphibious vehicle, using wireless joystick interface fo r vehicle movement.

POSITIONS OF RESPONSIBILITY

Teaching Assistant | Flight Testing Lab – 2025 | Prof. Sandeep Saha **[Jan'25-Ongoing]**
- **UAV Projects:** Formulated and helping in executing projects on unmanned aerial vehicles ranging from blimps, VTOLS and fixed wings. The projects includes intelligent control of blimps using ionic thrusters, forest cover analysis, long endurance vehicle and ground effect vehicle design, & last mile delivery solutions.

Teaching Assistant | AI for CPS | Prof. Prabhat Kumar Mishra **[Jan'25-Ongoing]**
- **Guidance:** Assisting students in formulating & executing projects in robotics, with integration of AI with physical systems, with focus on Autonomy of Robots.

Teaching Assistant | Viscous Flow Theory | Prof. Sandeep Saha **[July'24-Ongoing]**
- **Deep Learning:** Delivered two lectures on applying deep learning for fluidic sciences with hands on approach. Topics included PINNs and Neural Operators.
- **Spectral Method:** Taught one lecture on fundamentals of spectral methods and on solving partial differential equations using Chebyshev Polynomials.

Teaching Assistant | Flight Testing Lab – 2024 | Prof. Sandeep Saha **[Jan'24-Apr'24]**
- **Flight Testing Lab**: A lab focusing on engineering and practical applications with fixed wings and quadrotors. Built autonomous fixed-wing aircraft for the lab.
- **Problem Formulation**: Guided students in formulating and solving UAV based real-life challenges, emphasizing on practical issues in autonomous systems.
- **Inventory Management**: Built & managed lab inventory for electronics and fixed-wing components, to ensure organized and accessible resources for the lab.

Head Member | Aerial Robotics Kharagpur (ARK) **[Apr'23-Ongoing]**
- **Team Management**: Led ARK team for UAV subsystem development, and conducted sessions on Embedded, Autonomous Systems, and Computer Vision.
- **Competition Guidance**: Guided teams for IMAV 2023 (10 members) and ICUAS 2024 (3 members) drone competitions, for embedded and control system.

AWARDS AND ACHIEVEMENTS

- **IndiaAI Mission Fellowship | Ministry of Electronics & Information Tech., Gov. of India -** Recieving fellowship of ₹2,00,000 for the duration - **[Oct'24-Jul'25]**
  Project: Neural Operator Assisted Spectral Method Solver for Partial Differential Equations with Complex Interface Geometry. **[Work in Progress]**

- **CHANAKYA Fellowship | AI4ICPS, India -** Recieved fellowship amount of ₹30,000 for the duration - **[May'24-Jul'24]**
  Project: Built Data Acquisition System (Multiple IMU, EMG, FSR, Encoders) for Lower Limb Prosthetics & developed impedance controller. **[Delivered]**

- **MITACS Globalink Research Internship | Canada -** Recieved fellowship amount of $9000 for the duration - **[May'23-Jul'23]**
  Project: Cooperated Automatic Driving Testbed - Built Autonomous Stack for Cooperative Driving. **[Delivered]**

SKILLS AND EXPERTISE

•Expertise: Robotics | Autonomous Systems | Data-Driven Approaches and Machine Learning | Unmanned Aerial Vehicles | Aerodynamics | Control Systems | Embedded Systems | Image Processing | Scientific Computing | **• Skills:** C++, Python, C, Assembly, MATLAB, LATEX, AVR-C, AVR-ASM, STM32 - C++, Fortran | **Parallel Computing**: OpenMP, OpenMPI, CUDA | **Robotics Tools:** ROS/ROS2, PX4, CasADi, OpenCV, Gazebo, NVIDIA Isaac **| Design and Modelling:** MATLAB, Simulink, Ansys Fluent, Proteus, Fritzing **| Development Boards:** Raspberry Pi, Jetson, AVR, STM32s, ESP32/ESP8266, LoRa

EXTRA-CURRICULARS

- **Rangoli Making (Gold):** Designed algorithm for rangoli design using Machine Learning and Computer Vision for making different art appear based on lighting.
- **Robotics Presentation**: Presented my work on Robotic Serial Manipulators for PANDA (Paper Analysis & Discussion in AI) to the research scholars of AI Dep.
- **MATLAB Workshop**: Conducted workshop in the Aerospace Department for Freshers and Sophomores on "*MATLAB For Aerospace Applications*".